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(54) Valved discharge mechanism of a refrigerant compressor.

(57) A refrigerant compressor includes a compressor housing defining a chamber in which successive strokes of sucking, compressing, and discharging a refrigerant gas is repeatedly performed. The chamber is divided into a compression chamber and a discharge chamber by a valve plate. Discharge hole links a compression chamber to a discharge chamber. The valve plate includes an end surface which faces the discharge chamber. Discharge valve regulates a flow of the refrigerant gas from the compression chamber to the discharge chamber. The valve retainer limits the bending movement of the discharge valve in the direction in which the refrigerant gas leaves from one end opening of the discharge hole. The valve retainer is secured to the axial end surface of the valve plate together with the discharge valve by fixing bolt. The discharge valve bends to block and open one end opening of the discharge hole. The valve plate includes an annular groove formed at the on end surface thereof. The annular groove surrounds the discharge hole and is entirely overlaid with the discharge reed valve. Also, an air gap may be designed to be created between the discharge reed valve and the valve plate. Thereby, the noise of resonance vibration caused from discharge valve mechanism can be effectively reduced.

FIG.4

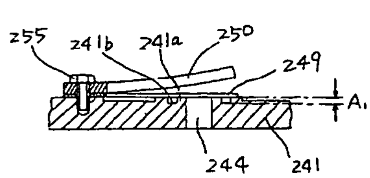
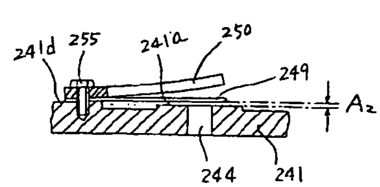


FIG. 6



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The present invention relates to a refrigerant compressor and, more particularly, to a valved discharge mechanism of a refrigerant compressor used in in automotive air conditioning system.

The valved discharged mechanism of a refrigerant compressor are well known in the prior art. For example, U.S. Pat. No.4,815,952 discloses a structure and operational mechanism of the valved discharge mechanism of a refrigerant compressor. As disclosed therein, referring to Figure 2 and 3, a refrigerant compressor includes a compressor housing defining a compression chamber in which successive strokes of sucking, compressing, and discharging a refrigerant gas is repeatedly performed. Further, a compressor includes a valve plate which is formed to partition the compression chamber and the discharge chamber and a discharge valve assembly which is mounted on the upper surface of valve plate 241. Valve plate 241 has discharge hole 244 extending therethrough and communicating the compression chamber with the discharge chamber. The discharge valve assembly includes discharge reed valve 249 and valve retainer 250 which are secured together to the upper surface of valve plate 241 by fixing bolt 255. Valve plate 241 includes valve seat 241a in the upper surface around discharge hole 244. Discharge reed valve, which is made of elastic material, regulates the flow of the refrigerant gas and makes sealing contact against valve seat 241a without air gap when the operation Of compressor is stopped.

Valve retainer 250 limits the bending movement of discharge reed valve 249 in the direction in which the refrigerant gas leaves from one end opening of discharge hole 244. Discharge reed valve vends to block and open one end opening of discharge hole 244, and has a predetermined value of elastic modulus which allows discharge reed valve 249 to keep blocking one end opening of discharge hole 244 until a pressure in the compression chamber reaches a predetermined value.

The amount of the air gap between the under surface of discharge reed valve 249 and the upper surface of valve seat 241a is increased and decreased corresponding to the velocity of the discharge refrigerant gas exhausted from discharge reed valve 249 through discharge hole 244, which is varied with the rotational speed of the compressor. In this arrangement, according to experiments by the present inventor, it is confirmed that the magnitude of the discharge pulsation in the compressed refrigerant gas becomes particularly large at a frequency band of approximately 10-14kHz.

As a result, the compressor causes the vibration noise at high frequency band and propagates to the passenger compartment of the vehicle as an offensive noise.

It is an object of the present invention to provide a refrigerant compressor for use in an automotive air conditioning system having a valved discharge mechanism which can effectively reduce the vibration noise caused from a discharge vale assembly and thus, reduce the propagation of an offensive noise to a passenger compartment of a vehicle.

It is a further object of the present invention to provide a refrigerant compressor having a valved discharge mechanism wherein a life of a discharge reed valve is prolonged.

According to the present invention, a refrigerant compressor includes a compressor housing defining a chamber in which successive strokes of sucking, compressing, and discharging a refrigerant gas is repeatedly performed. The chamber is divided into a compression chamber and a discharge chamber by a valve plate. Discharge hole links a compression chamber to a discharge chamber. The valve plate includes on end surface which faces the discharge chamber. Discharge valve regulates a flow of the refrigerant gas from the compression chamber to the discharge chamber. The discharge valve is made of elastic material. The valve retainer limits the bending movement of the discharge valve in the direction in which the refrigerant gas leaves from one end opening of the discharge hole. The valve retainer is secured to the axial end surface of the valve plate together with the discharge valve by fixing bolt. The discharge valve bends to block and open one end opening of the discharge hole. The discharge valve has a predetermined value of elastic modulus which allows it to keep blocking one end opening of the discharge until a pressure in the compression chamber reaches a predetermined value.

The valve plate includes an annular groove formed at the on end surface thereof. The annular groove surrounds the discharge hole and is entirely overlaid with the discharge reed valve. Also, an air gap may be designed to be created between the discharge reed valve and the valve plate.

Further objects, features and other aspects of the present invention will be understood from the detailed description of the preferred embodiment of the present invention with reference to the annexed drawings, in which:-

Figure 1 is a longitudinal sectional view of a scroll refrigerant compressor in accordance with the present invention.

Figure 2 is a sectional view of a discharge valve assembly in accordance with the prior art.

Figure 3 is a plan view of the discharge valve assembly shown in Figure 2.

Figure 4 is a sectional view of a discharge valve assembly in accordance with the first embodiment of the present invention.

Figure 5 is a plan sectional view of a discharge valve assembly shown in Figure 4.

Figure 6 is a sectional view of a discharge valve assembly in accordance with the second embodiment of the present invention.

Figure 7 is a plan sectional view of a discharge valve assembly shown in Figure 6.

Figure 8 is a sectional view of a discharge valve assembly in accordance with the third embodiment of the present invention.

Figure 9 is a sectional view of a discharge valve assembly shown in Figure 4 but showing a length of a air columnar of discharge valve and the velocity of a fluid in the air gap between the discharge valve and the valve seat.

Figure 10 is a plan sectional view of discharge valve assembly shown in Figure 9.

Figure 11 is graphical illustration of a relationship between air gap d and time t, and a graphical illustration of relationship between the magnitude of the vibration of the compressor in accordance with the prior art.

Figure 12 is a sectional view of a discharge valve assembly shown in Figure 4 but showing a length L of a air columnar of discharge valve divided into.

Figure 13 is a sectional view of discharge valve assembly shown in Figure 6 but showing the discharge valve adhered to the valve seat.

Figure 14 is graphical illustration of a relationship between air gap d and time t, and a graphical illustration of relationship between the magnitude of the vibration of the compressor in accordance with the second embodiment of the present invention.

Figure 1 illustrates a fluid displacement apparatus in accordance with the present invention, in particular a scroll type fluid displacement apparatus 1 according to one embodiment of the present invention. The apparatus 1 includes a housing 10 comprising a front end plate member 11 and a cup-shaped casing 12 which is disposed on one end surface of front end plate member 11. An opening 111 is formed in the center of front end plate member 11 for penetration or passage of a drive shaft 13. An annular projection 112 is formed on the rear end surface of front end plate member 11 which faces casing 12. An outer peripheral surface of annular projection 112 fits into an inner wall surface of the opening portion of casing 12. Casing 12 is fixed on the rear end surface of front end plate member 11 by a fastening means, for example bolts (not shown), so that the opening portion of casing 12 is covered by front end plate member 11. An O-ring member 14 is disposed between the outer peripheral surface of annular projection 112 and the inner wall surface of casing 12, to thereby effect a seal between the fitting or mating surfaces of front end plate member 11 and casing 12.

Front end plate member 11 has an annular sleeve portion 15 projecting from the front end surface thereof for surrounding drive shaft 13 to define a shaft seal cavity. In this embodiment, sleeve portion 15 is separate from front end plate member 11. Therefore, sleeve portion 15 is fixed to the front end surface of front end plate member 11 by a plurality of screws (not shown). O-ring 16 is disposed between the end surface of front end plate member 11 and sleeve portion 15. Alternatively, sleeve portion 15 may be formed integral with front end plate member 11. Drive shaft 13 is rotatably supported by sleeve portion 15 through bearing 17 disposed within the front end portion of sleeve portion 15. Drive shaft 13 is formed with disk portion 131 at its inner end portion and disk portion 131 is rotatably supported by front end plate member 11 through bearing 18 disposed within opening 111 of front end plate member 11. Shaft seal assembly 19 is assembled on drive shaft 13 within the shaft seal cavity of sleeve portion 15. Pulley 20 is rotatably supported by sleeve portion 15 through bearing 21 which is disposed on the outersurface of sleeve portion 15. Electromagnetic coil 22 is fixed on the outer surface of sleeve portion 15 by support plate 221 and is received in an annular cavity of pulley 20. Amature plate 23 is elastically supported on the outer end portion of drive shaft 13 which extends from sleeve portion 15, Magnetic clutch comprising pulley 20, magnetic coil 22, and armature plate 23 is thereby formed.

Thus, drive shaft 13 is drive by an external power source, e.g., the engine of an automobile, through force transmitting means, such as the magnetic clutch. Fixed scroll member 24, orbiting scroll member 25, crank type driving mechanism 132 of orbiting scroll member 25, and rotation preventing mechanism 13 of orbiting scroll member 25 are disposed in an inner chamber of cup shaped casing 12. Fixed scroll member 24 includes circular end plate 241, wrap means or spiral element 242 affixed to and extending from one side surface of end plate 241, and a plurality of internally threaded bosses 243 axially projecting from the end surface of end plate 241 opposite to the side thereof from which spiral element 242 extends. The end surface of each boss 243 is seated on the inner surface of end plate portion 121 of cupshaped casing 12 and is fixed to end plate portion 121 by bolts 26.

Hence, fixed scroll member 24 is fixedly disposed within casing 12. Circular end plate 241 of fixed scroll member 24 partitions the inner chamber of casing 12 into discharge chamber 27 and suction chamber 28 by seal ring disposed between the outer peripheral surface of end plate 241 and

the inner wall of casing 12. Orbiting scroll member 25 is disposed within suction chamber 28 and also comprises circular end plate 251 and wrap means or spiral element 252 affixed to and extending from one side surface of end plate 251. Spiral element 252 and spiral element 242 of fixed scroll member 24 interfit at an angular offset of 180 and a predetermined radial offset. At least one pair of fluid pockets are thereby defined between spiral elements 242 and 252. Orbiting scroll member 25 is connected to the driving mechanism and the rotation preventing mechanism. These two mechanism effect orbital radius Ro (not shown) by rotation of drive shaft 13, to thereby compress fluid passing through the compressor unit. Each spiral element 242, 252 is provided with groove 30 formed in its axial end surface along the spiral curve. Seal element 31 is loosely fitted within groove 30. Sealing between the axial end surface of each spiral element and the inner end surface of the opposite end plate is effected by the seal element.

As above described, when orbiting scroll member 25 is allowed to undergo the orbital motion of radius by the rotation of drive shaft 13, line contacts between both spiral elements 242, 252 shift along the spiral curved surfaces so that the fluid pockets move to the center of the spiral elements.

Therefore, fluid or refrigerant gas, introduced into the suction chamber 28 from an external fluid circuit through an inlet port 32 on casing 12, is drawn into the fluid pockets formed between spiral elements 242 and 252. As orbiting scroll member 25 orbits, fluid in the fluid pockets is moved to the center of the spiral elements with a consequent reduction of volume. Compressed fluid is discharged into discharge chamber 27 from the fluid pockets at the center of the spiral elements through hole 244, which is formed through circular end plate 241 of fixed scroll member 24, at a position near the center of spiral element 242, past discharge reed valve 249, and is discharged therefrom through outlet port 33 formed on casing 12 to an external fluid circuit, g.e., a cooling circuit.

Referring to Figure 4 and 5, discharge valve assembly is provide within discharge chamber 27. Discharge valve assembly includes discharge read valve 249 and valve retainer 250 which are secured together to the axial end surface 241c of circular end plate 241 by fixing bolt 255. Circular end plate 241 includes valve seat 241a which is formed in axial end surface 241c around discharge hole 244 and annular groove 241b which is still formed in axial end surface 241c around valve seat 241a. The longitudinal axis of annular groove 241b is concentric with the longitudinal axis of discharge hole 244. Discharge reed valve 249 which is made of elastic material, e.g., thin spring steel; regulates a flow of the refrigerant gas and makes sealing contact against valve seat 241a. Valve retainer 250 limits the bending movement of discharge reed valve 249 in the direction which the refrigerant gas leaves from one end of discharge hole 244. Discharge reed valve 249 vends to block and open one end of discharge hole 244, and has a predetermined value of elastic modulus which allows discharge reed valve 249 to keep blocking one end of discharge hole 244 until a pressure in compression chamber 27 reaches a predetermined value. Further, discharge reed valve 249 includes end portion 249a which is dimensioned to be larger than the outer diameter of annular groove 241b so as to cover entirely the upper surface of annular groove 241b.

Then, it is consider that the noise of discharge valve in the prior art is caused as follow mechanism. In general, when a fluid forcibly jets from an opening of a tube, a karuman vortex streets are caused at a border region of circumferential medium. Thereby, the refrigerant gas which flows from the discharge hole to the discharge chamber causes a karuman vertex street at near the corner of the discharge hole. The vibration of refrigerant gas occurs with a specified frequency band by the karuman vertex street. This frequency band can be represented by the follow equation.

$$f = St \bullet V/D \qquad (1)$$

In this formula, f is a frequency of a vibration and St is Strouhal number which is related to Reynolds number. V is a velocity of medium, such as a refrigerant gas and D is a diameter of an opening which a fluid flows. Further, the air gap between the discharge valve and the valve seat are formed as a certain air columnar which has a natural frequency as the following equation. This natural frequency is only relation to length L, not the diameter of air columnar.

$$fn = n \bullet A/2L \qquad (2)$$

In this formula, fn is n order frequency and A is a sonic speed in a fluid gas. L is a length of air columnar.

Then, referring to Figure 9 and 10 in accordance with the prior art, velocity v of the refrigerant gas from discharge hole 244 to discharge chamber 27 through discharge reed valve 249 increase in proportion to the rotary speed of the compressor. Air gap d between discharge reed valve 249 and valve seat 241a is increased according to discharge reed valve 249 being lifted and opened by the discharge gas. Length L is a length of which discharge reed valve 249 is geometrically projected from upper direction and changed in accordance with discharge reed valve 249 being opened and closed.

Thereby, the above air columnar occurs a resonance vibration due to sympathizing the vibration of refrigerant gas which is caused the karuman vertex street as the equation 1 and 2. According to experiments by present inventors, it was confirmed that these vibration of various frequency are caused at the same time because Length L has a various value in all radial direction and the resonance of vibration are caused at the peak of the movement locus of the discharge valve as shown in Figure 11. Figure 11 illustrates the displacement of air gap d relation to time. Further, it was confirmed that the magnitude of the large vibration becomes particularly large when the discharge valve reaches the peak of the movement and the noise of this peak vibration become large at a frequency band of approximately 10-14Hz according to analyzing frequency.

In this embodiment, referring to Figure 12, the frequency of which the resonance vibration are caused by L1, L2, L3, L4, L5, and L6 are respectively high frequency band because length L of air columnar is divided into L1, L2, L3, L4, L5, and L6 at groove 241a as a border. These frequency are beyond the scope of auditory sensation area. As a result, the noise of resonance of vibration become to be vanished. Further, the depth A1 of annular grove 241b is required to be more than 0.15 mm so as to perform varnishing the noise of resonance of vibration.

Figure 6 and 7 illustrates second embodiment of the valve discharge mechanism of scroll type refrigerated compressor. In this embodiment, circular end plate 241 divides axial end surface 241c and fixing surface 241d to which discharge reed valve 249 and valve retainer 250 are secured together. Fixing surface 241d is formed to be higher than axial end surface 241c so that air gap A2 is axially created between the under surface of discharge reed valve 249 and axial end surface 241c. Also,end portion 249a of discharge reed valve 249 may be designed to be axially offset so that air gap A2 is axially created between the under surface of discharge reed valve 249 and axial end surface 241c. The surface of which discharge reed valve 249 faces to valve seat 241a is parallel to axial end surface 241c of valve seat 241a.

Also, when the operation of compressor is stopped, there are a predetermined air gap between discharge reed valve 249 and valve seat 241a. However, once the operation of compressor begin to start, the pressure of discharge chamber 27 is gradually increased and consequently to be higher than the integrated pressure force which the pressure in compression chamber 245 is added to the restoring force of discharge reed valve 249, while discharge reed valve 249 is opened and closed in several times. After that time, discharge reed valve 249 constantly starts to be open from such condition of which discharge reed valve 249 adhere to valve seat 241a as well as the condition which a predetermined air gap is not provided with as shown Figure 13.

In this arrangement, it was confirmed that the movement locus of the air gap d dose not rise above the peak of the movement of the discharge valve in the prior art because the compression gas flow out from compression chamber 245 at a stretch due to lifting discharge reed valve 249 by the restoring force of discharge reed valve 249 and the noise of resonance of vibration is not caused duo to this movement of discharge reed valve 249, as shown Figure 14. Also, the noise of the compressor become to be varnished because this movement of discharge valve are beyond the scope of the area which the noise of vibration are caused, this scope is formed due to a relationship between velocity v of the refrigerant gas and air gap d. The value of air gap d is required to be more than 0.15 mm so as to perform vanishing the noise of resonance vibration.

Figure 8 illustrates third embodiment of the valve discharge mechanism. This embodiment includes both first embodiment and second embodiment,i.e., annular groove 241b which is still formed in the surface around valve seat 241a. Discharge reed valve 249 includes end portion 249a which is dimensioned to be larger than the outer diameter of annular groove 241b so as to cover entirely the upper surface of annular groove 241b. Fixing surface 241d is axially offset and higher than axial end surface 241c. Air gap A2 is designed to be axially created between the under surface of discharge reed valve 249 and axial end surface 241c. Therefore, this embodiment provides the advantages which is more reliable than the first embodiment and the second embodiment in concern with the noise of the resonance of the vibration.

Furthermore, in the second embodiment and third embodiment, a life of discharge reed valve 249 become to be long-lifed because discharge reed valve 249 softly contact valve seat 241a by the restoring force of discharge valve 249.

Although the present invention has been described in connection with the preferred embodiment; the invention is not limited thereto. It will be easily understood by those of ordinary skill in the art that variations and modifications can be easily made within the scope of this invention as defined by the appended claims.

Claims

1. In a refrigerant compressor including a compressor housing defining a chamber in which successive strokes of sucking, compressing,

and discharging a refrigerant gas is repeatedly performed;

said chamber being divided into a first chamber and second chamber in which a discharge chamber is defined by a valve plate;

said valve plate including one end surface which faces said discharge chamber;

linking means for linking said first chamber to said discharge chamber;

regulating means for regulating a flow of said refrigerant gas from said first chamber to said discharge chamber;

said linking means including a conduit communicating said first chamber with said discharge chamber;

regulating means including a plate member made of elastic material and a retainer member limiting the bending movement of said plate member in the direction in which said refrigerant gas leaves from said one end opening of said conduit;

said retainer member secured to said on end surface of said valve plate together with said plate member by fixing means;

said plate member bending to block and open said one end opening of said conduit;

said plate member having a predetermined value of elastic modulus which allows said plate member to keep blocking said one end opening of said conduit until a pressure in said first chamber reaches a predetermined value, the improvement comprising:

said valve plate including an annular groove formed at said on end surface thereof,

said annular groove which surrounds said conduit and is entirely overlaid with said plate member.

2. The refrigerant compressor of claim 1 wherein the longitudinal axis of said annular groove is concentric with the longitudinal axis of said conduit.

3. In a refrigerant compressor including a compressor housing defining a chamber in which successive strokes of sucking, compressing, and discharging a refrigerant gas is repeatedly performed;

said chamber being divided into a first chamber and second chamber in which a discharge chamber is defined by a valve plate;

said valve plate including one end surface which faces said discharge chamber;

linking means for linking said first chamber to said discharge chamber;

regulating means for regulating a flow of said refrigerant gas from said first chamber to said discharge chamber;

said linking means including a conduit communicating said first chamber with said discharge chamber;

regulating means including a plate member made of elastic material and a retainer member limiting the bending movement of said plate member in the direction in which said refrigerant gas leaves from said one end opening of said conduit;

said retainer member secured to said one end surface of said valve plate together with said plate member by fixing means;

said plate member bending to block and open said one end opening of said conduit;

said plate member having a predetermined value of elastic modulus which allows said plate member to keep blocking said one end opening of said conduit until a pressure in said first chamber reaches a predetermined value, the improvement comprising:

an air gap being created between said plate member and said valve plate.

4. The refrigerant compressor of claim 3, said plate member having one end surface which faces said one end surface of said valve plate, wherein said one end surface of said plate member is parallel to said one end surface of said valve plate.

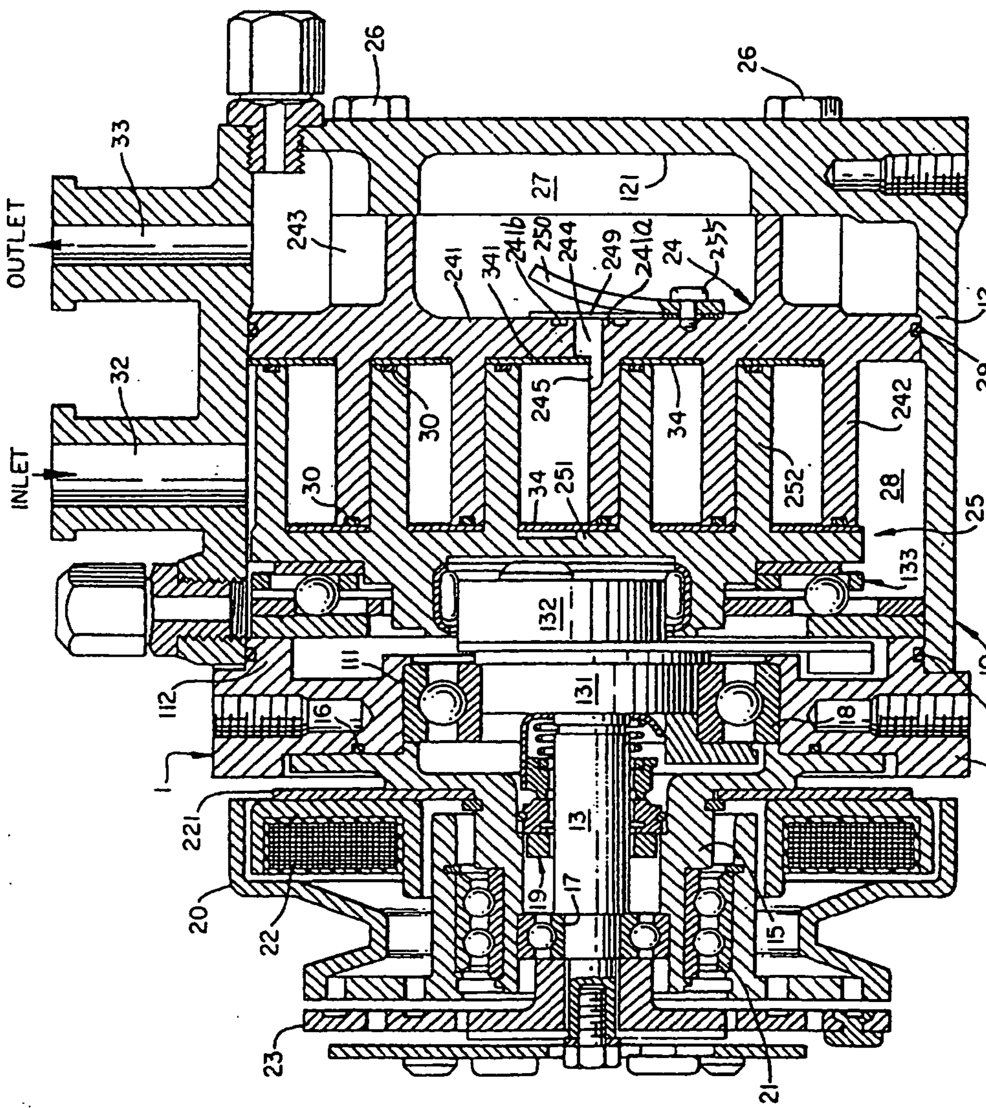

OUTLET
INLET
33
32
26
26
27
121
243
241
341
241b
250
244
249
241a
24
255
245
30
30
34
34
251
252
242
28
25
12
29
133
132
131
111
112
16
18
10
14
1
11
221
20
22
13
17
19
15
23
21

FIG. 1

FIG.2
(Prior Art)

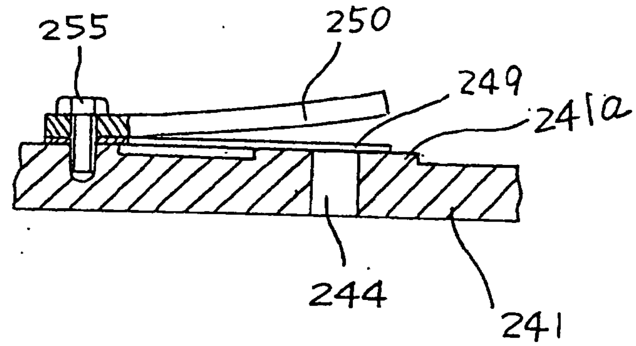


FIG.3
(Prior Art)

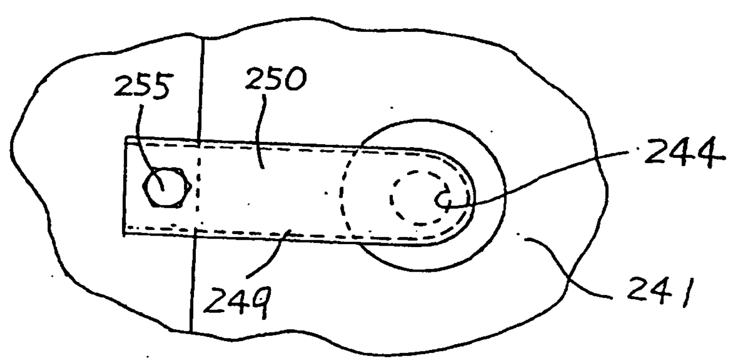


FIG.4

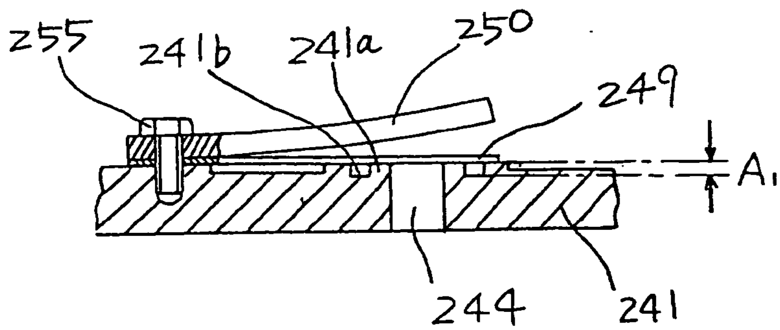

255
241b
241a
250
249
A1
244
241

FIG.5

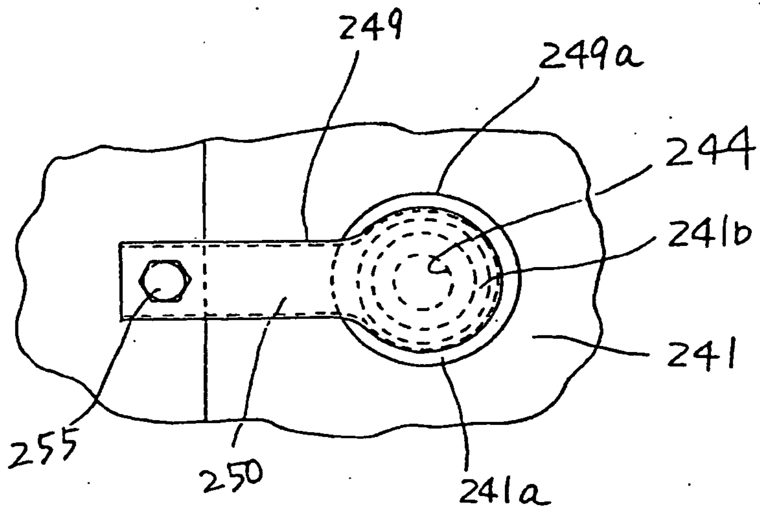

249
249a
244
241b
241
255
250
241a

FIG. 6

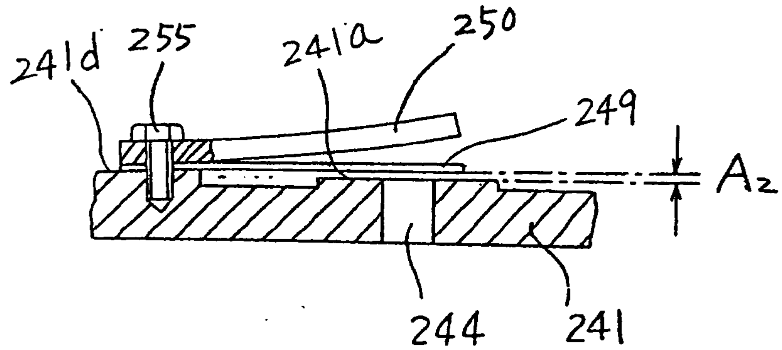


FIG. 7

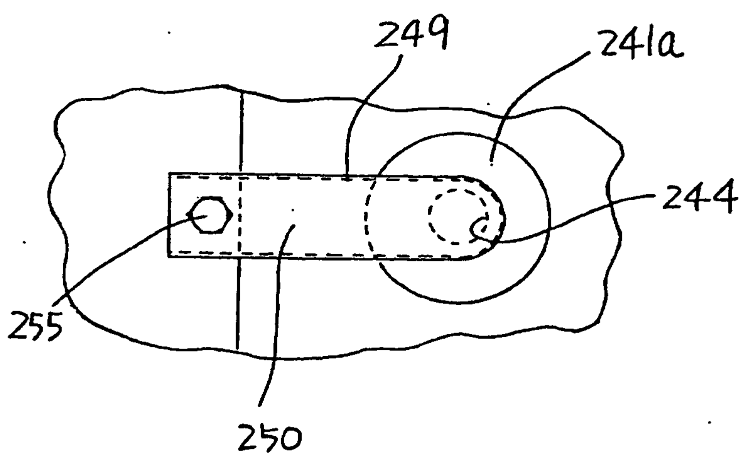


FIG. 8

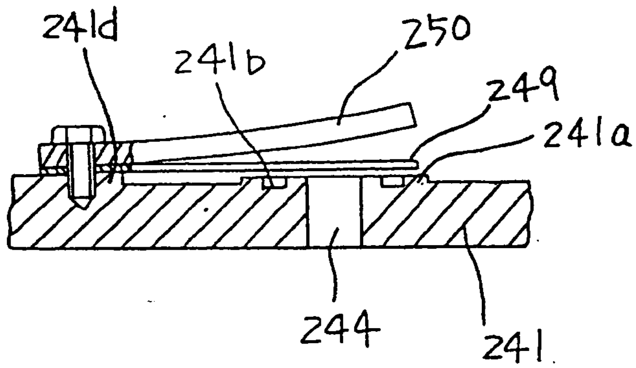


FIG. 9

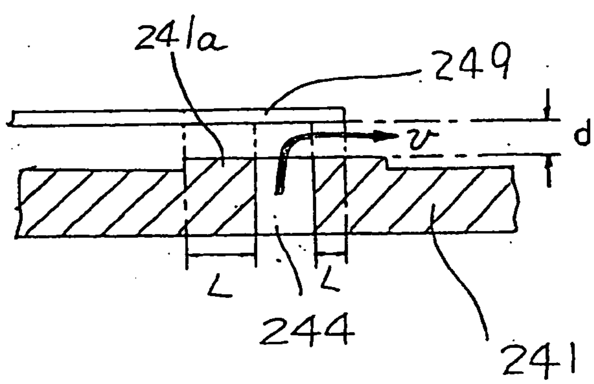


FIG. 10

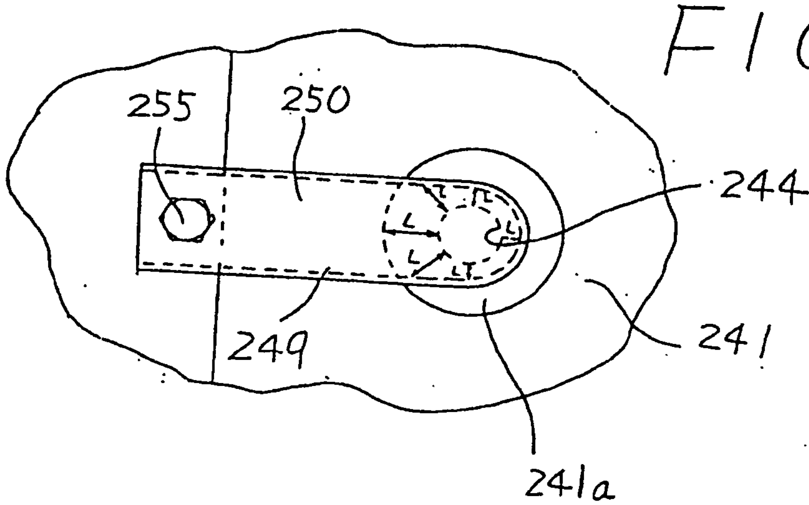

255
250
244
L
249
241
241a

FIG. 11

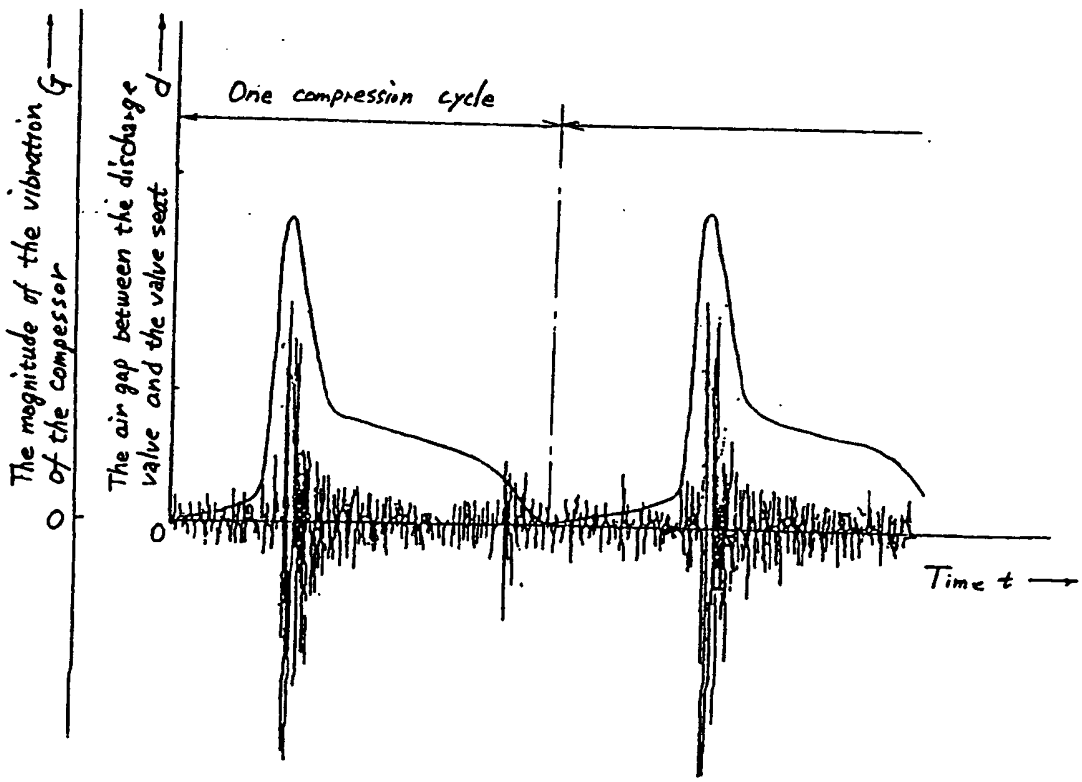

The magnitude of the vibration of the compessor G
The air gap between the discharge valve and the valve seat d
One compression cycle
0
0
Time t

FIG. 12

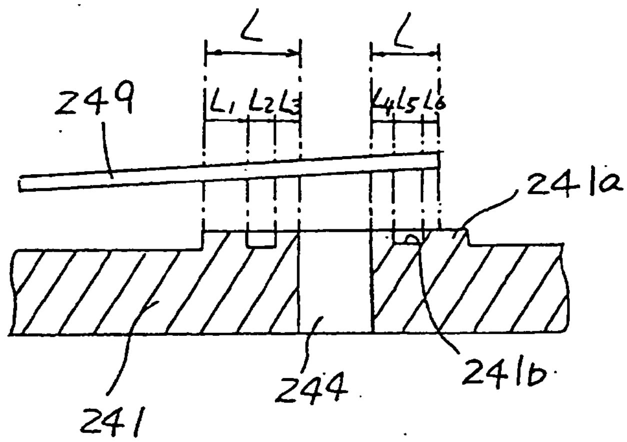

L
L
249
L1 L2 L3
L4 L5 L6
241a
241
244
241b

FIG. 13

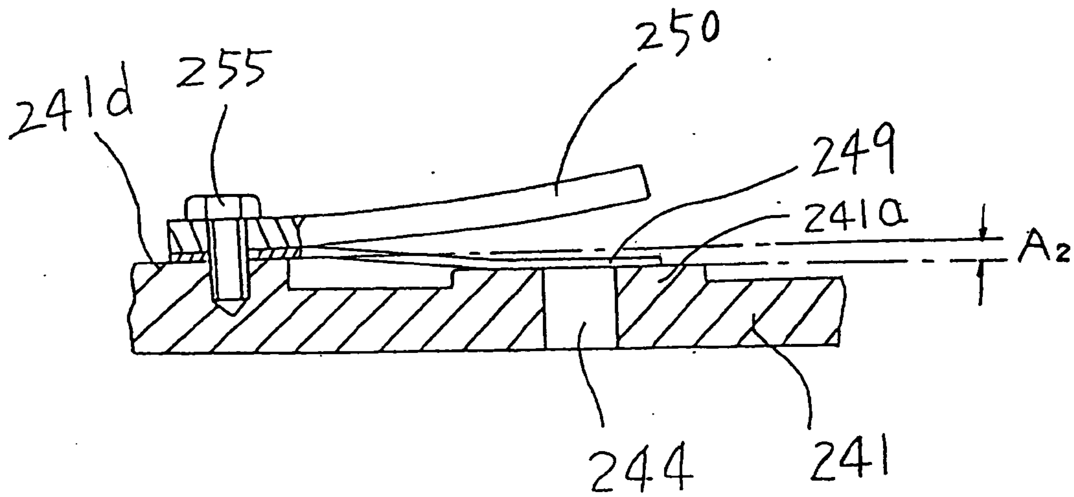
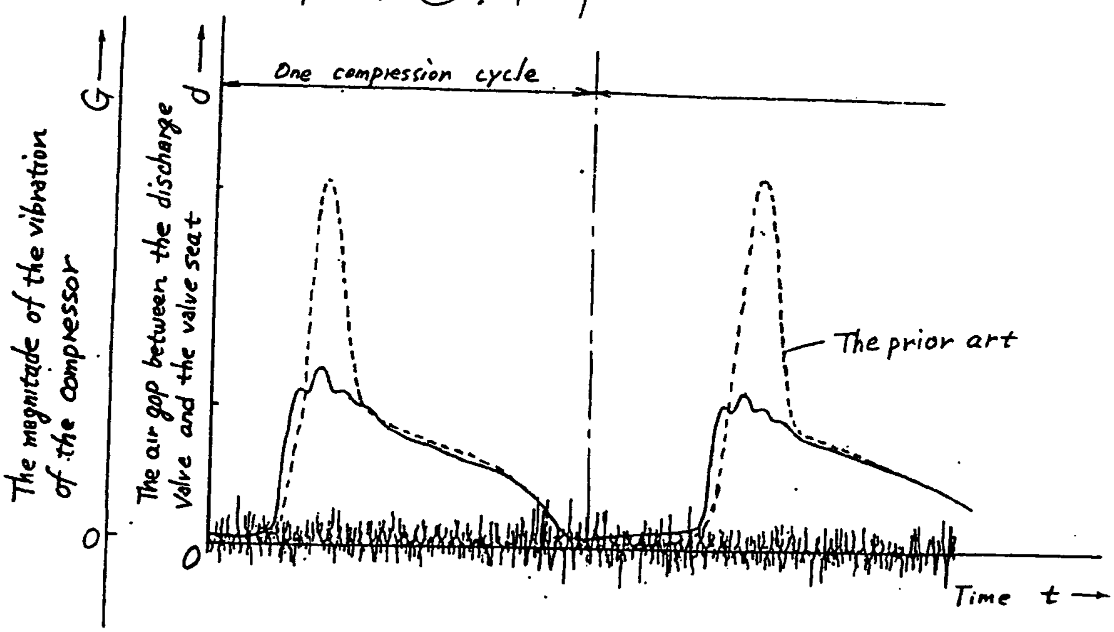

250
241d
255
249
241a
A2
244
241

FIG. 14


The magnitude of the vibration of the compressor
G
0
The air gap between the discharge valve and the valve seat
d
0
One compression cycle
The prior art
Time t

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 7447

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	US-A-2 154 880 (TWIGG) * the whole document *	1,2	F04C29/08 F04C18/02
X	US-A-3 606 588 (ROMERHAUS) * the whole document *	3,4	
A	US-A-3 040 973 (WESSLING) * the whole document *	3,4	
A	US-A-4 955 797 (COWEN) * the whole document *	1-4	
A	DE-A-40 07 371 (EMPRESA BRASILEIRA DE COMPRESSORES S.A.) * the whole document *	1-4	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5) F04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 December 1993	Dimitroulas, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document